Ethical, Legal & Social Issues

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Critical review

Epigenetics, evolution and embodiment: on the conceptual vacuity of evolutionary psychology

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Abstract

Introduction

We summarize briefly contemporary scientific advances in evolutionary biology and epigenetics, and discuss their implications for revising scholarly understanding of human development, especially when framed within relational developmental systems theories. We contrast the evidence in support of a relationally-integrated approach to biological and behavioural (psychological and social) processes with claims about links between evolution and human development emanating from an area of social/behavioural science, Evolutionary Psychology. We note the conceptual and empirical problems of Evolutionary Psychologyand, in turn, highlight the empirical utility of integrated biological and developmental science research framed by relational developmental systems theories.

Conclusion

We make recommendations for future, multidisciplinary research framed by relational developmental systems theories, and point to the implications of data derived from such work for applications to social policies and programmes.

Introduction

Contemporary scientific advances in evolutionary biology and epigenetics have profound implications for describing, explaining, and optimising human development[1]. Increasingly over the last 10 to 15 years, innovative and important theoretical and empirical advances in the study of evolutionary biology and genetic processes have changed the understanding of human phylogeny and ontogeny. These advances have significant implications for human health and welfare, and rest to no small degree on the links within arevised, multi-dimensional understanding of human evolution[2,3,4], epigenetic processes that constitute alterations in the functional impacts of genes across both the lifespan and generations[5,6,7] and human development; and culture[4,5,8]. The aim of this review is to discuss the conceptual vacuity of evolutionary psychologyin light of these advances.

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Evolution, epigenetics, and human development

Contemporary scholarship on the character of evolution reflects the concept of *embodied* change within the relational developmental system. Forexample, Bateson and Gluckman[9] observe that, "gene expression is profoundly influenced by factors external to the cell nucleus in which reside the molecules making up the genes: the deoxyribonucleic acid (DNA). A willingness to move between different levels of analysis has become essential for an understanding of development and evolution." Similarly, Keller[10] explains that, "Everything we know about the processes of inheritance and development teaches us that the entanglement of developmental processes is not only immensely intricate, but it is there from the start. From its very beginning, development depends on the complex orchestration of multiple courses of action that involve interactions among many different kinds of elements – including not only pre-existing elements (e.g., molecules) but also new elements (e.g., coding sequences) that are formed out of such interactions, temporal sequences of events, dynamical interactions, etc."

Moreover, Pigliucci and Müller[11] note that there is a, "view of 'genes as followers' in the evolutionary process, ensuring the routinisation of developmental interactions, the faithfulness of their inheritance, and the progressive fixation of phenotypic traits that were initially mobilised through plastic responses of adaptive developmental systems to changing environmental conditions. In this way, evolution progresses through the capture of emergent interactions into genetic-epigenetic circuits, which are passed to and elaborated on in subsequent generations."

Similarly, West-Eberhard[12] explains that, "environmental induction is a major initiator of adaptive evolutionary change. The origin and evolution of adaptive novelty do not await mutation; on the contrary, genes are followers not leaders, in evolution . . . Novel traits are not de novo constructions that depend on a series of genetic mutations . . . phenotypic plasticity can facilitate evolution by the immediate accommodation and exaggeration of change. It should no longer be regarded as a source of noise in a system governed by genes, or as a 'merely environmental' phenomenon without evolutionary importance."

Crystallising the embodiment of variables from all levels of organisation within relational developmental

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systems that create epigenetic change across generations, Jablonka and Lamb[4] summarize evidence demonstrating that evolution involves four interrelated dimensions: "Molecular biology has shown that many of the old assumptions about the genetic system, which is the basis of present-day neo-Darwinian theory, are incorrect. It has also shown that cells can transmit information to daughter cells through non-DNA (epigenetic) inheritance. This means that all organisms have at least two systems of heredity. In addition, many animals transmit information to others by behavioural means, which gives them a third hereditary system. We humans have a fourth, because symbol-based inheritance, particularly language, plays a substantial role in our evolution. It is therefore quite wrong to think about heredity and evolution solely in terms of the genetic system. Epigenetic, behavioural, and symbolic inheritance also provide variation on which natural selection can act."

Accordingly, in a book discussing the transformations of Lamarckian theory that have arisen in relation to the increasingly more active focus on epigenetic processes in the study of both evolution and development, Gissis and Jablonka[2] note that, "Plasticity – the capacity of organisms to change in response to varying conditions – is . . . a large topic, but, just as Lamarck anticipated, an understanding of plasticity is now recognised as being fundamental to an understanding of evolution." They go on to note that, "a form of 'inheritance of acquired characteristics' does occur and might even be said to be ubiquitous. In particular, new variations induced by stress are sometimes inherited. The molecular mechanisms that underlie such inheritance – the epigenetic inheritance systems – are now partially understood, and . . . the existence of various types of [such] soft inheritance affects how we see adaptive evolution and speciation. It also has implications for human health."

The epigenetic process to which Gissis and Jablonka[2] refer involves heritable changes in genome activity (i.e., changes that are transmittable across generations) that are caused by modifications of DNA or of core histones (the structures around which DNA is wrapped within the cell nucleus) through chemical processes such as methylation or acetylation[13].

Moreover, Slavich and Cole[8] point to the growing research onhuman social genomics, a field that documents, "changes in the expression of literally hundreds of genes . . . as a function of the physical and social environments we inhabit." In addition, Slavich and Cole[8] point to findings with both animals and humans that indicate that social influences promote alterations in methylation process and in core histones and, quite provocatively for those interested in the application of developmental science, they note that, "psychological interventions can reverse stress-induced genome wide transcriptional processes."

In short, there is now an overwhelming amount of evidence in support of the epigenetic character of evolution and ontogeny, of the multiple, integrated dimensions of evolution, and of the role of the organism's own embodied action and of culture in creating change within and across generations. The embodied acts of the individual and the individual's relatively plastic developmental biological and psychological processes,which operate within the relational developmental system, provide the basis for epigenetics across generations and offer great opportunities for developmental scientists, in collaboration with biologists interested in human epigenetics, to promote positive human development[14]. In these collaborations, scientists using a relational metatheory have developed a set of models–summarised under the rubric, "relational developmental systems theories"–to frame their work.

Relational Developmental Systems Theories

The study of human development has evolved from a field dominated by opposing psychogenic vs. biogenic approaches to a collaborative multidisciplinary approach to the lifespan that seeks to integrate variables from the biological through the cultural and historical levels of organisation into a synthetic, coactionalsystem[15,16]. Reductionist accounts of development that adhere to an increasingly anachronistic Cartesian-Mechanistic paradigm that dichotomizes (splits), facets of the integrated developmental system into opposing alternatives, are rejected by proponents of relational developmental systems theorists[17].

The conceptual emphasis of relational developmental systems theories (RDST) is placed on the nature of bidirectional mutually-influential relations between the organism and contexts, represented as organism ↔ context relations. All levels of the relational developmental system are integrated within such models[6,8,13]. These levels range from variables involved in biological/physiological processes, through behavioural and social relational processes, to physical ecological, cultural, and historical processes[18]. The embeddedness of all levels within history imbues temporality into organism ↔ context relations, and it means that there is a potential for plasticity, for organised and systematic change in these relations, across person, time, and place[15,19]. Thus, RDST focus on the "rules", the processes that govern all exchanges between organism and context. Brandtstädter[20] terms these relations, "developmental regulations", and notes that, when developmental regulations involve mutually-beneficial organism ↔ context relations, they constitute "adaptive" developmental regulations. The possibility of adaptive developmental relations between organism and context, and the potential plasticity of human development,

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are distinctive features of this approach to human development.

The persistence of reductionist and counterfactual accounts of the role of evolutionary biology and genetics in human development

The contemporary study of evolutionary biology and epigenetics, especially when embedded in models derived from relational metatheory, such as RDST[17], necessarily evokes an extreme scepticism about claims made by some biological reductionists. However, despite the counter evidence, reductionist evolutionary accounts continue to appear in the scientific literature. A case in point is evolutionary psychology (EP), an area of social/behavioural science that purports to be linked to information on evolution and continues to have some traction in this field[21,22]. As Rose and Rose[23] noted, EP claims that, "everything from children's alleged dislike of spinach to our supposed universal preferences for scenery featuring grassland and water derives from [the] mythic human origin in the African savannah". These claims are predicated on the basis of the assertion that one can explain: "all aspects of human behaviours, and thence culture and society, on the basis of universal features of human nature found their final evolutionary form during the infancy of our species some 100–600,000 years ago. Thus for EP, what its protagonists describe as the,"architecture of the human mind", which evolved during the Pleistocene is fixed, and insufficient time has elapsed for any significant subsequent change. In this architecture, there have been no major repairs, no extensions, no refurbishments, indeed nothing to suggest that micro or macro contextual changes since prehistory have been accompanied by evolutionary adaption[23]."

Clearly, such assertions within EPare inconsistent with the now quite voluminous evidence in support of the epigenetic character of evolution and ontogeny; the multiple, integrated dimensions of evolution; and the role of the organism's own agency and of culture in creating change within and across generations. Nevertheless, examples of the misguided scholarship of EP continue to appear in the literature. An example of the extreme nature of the claims of evolutionary psychologists is found in writings about what has been termed, "paternal investment theory"[24,25,26,27]. Thus, Elliset al.[28] state that: "paternal investment theory links low male parental investment to more aggressive and hyper masculine behaviour in sons and more precocious and RSB [risky sexual behaviour] in daughters[26,27]. The assumption is that natural selection has designed boys' and girls' brains to detect and encode information about their fathers' social behavior and role in the family as the basis for calibrating socio–sexual development in gender-specific ways."

The purported mechanism for what Ellis et al.[28] term this evolutionary-developmental process is that there is a unique role for "fathers" in regulating daughters' sexual behaviour. The theoretical basis for emphasising father effects is that: (a) the quality and quantity of paternal investment is, and presumably always has been, widely variable across and within human societies; (b) this variation recurrently and uniquely influenced the survival and fitness of children during our evolutionary history . . .; and (c) the variability in paternal investment, much more than maternal investment, was diagnostic of the local mating system (degree of monogamy vs. polygyny) and associated levels of male–male competition . . .. The mating system is important because more polygynous cultures and subcultures are characterised by heightened male intrasexual competition, dominance-striving, and violence, with concomitant diminution of paternal involvement and investment[26,27]. In turn, female reproductive strategies in this context are biased toward earlier sexual debut, reduced reticence in selecting mates, and devaluation of potential long-term relationships with high-investing males, all of which translate into more RSB."

However, the embodiment[17] of the organism and the organism's relatively plastic developmental biological, psychological, and behavioural processes within the relational developmental system provides a basis for epigenetic change that can reach across generations[6,7,13]. Thus,the continuity across eons postulated by Ellis, et al.[28] may reflect the "Just So" stories discussed by Gould[29]. As Myers[30] points out, "The repertoire of human behaviour is so complex and rich, and relatively recently evolved, that to argue that every behaviour is the product of specific selection imposes an untenable genetic load." The explanation given by Ellis, et al.[28] illustrates that EP accounts of the role of evolution and genetics in human development are conceptually flawed. Further, in ignoring contemporary findings concerning evolutionary processes and their impact on ontogeny[2,6], these EP accounts are empirically counterfactual.

In short, the embodiment of genetic processes within the relational developmental system provides the basis for epigenetic change within the lifespan of an organism and for qualitative discontinuities across generations in relations among biological, psychological, behavioural, and social variables. Evidence for the relative plasticity of human development within the integrated levels of the ecology of human development has important implications for research and applications.

Discussion

The authors have referenced some of their own studies in this review. These referenced studies have been conducted in accordance with the

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Declaration of Helsinki (1964) and the protocols of these studies have been approved by the relevant ethics committees related to the institution in which they were performed. All human subjects, in these referenced studies, gave informed consent to participate in these studies.

Implications for research and programme and policy applications

Current research in evolutionary biology, epigenetics, and developmental science, especially when understood within a RDST perspective, coalesce to indicate that split, biological (e.g., genetic) reductionist ideas are fundamentally flawed. Genes are not the to-be-reduced-to entities providing any "blueprint" for behaviour or development[6], nor do they function as a "master molecule"[5,6]. Further, genes are not the context-independent governors of the "lumbering robots"[31] housing them; and they are not the fixed material basis of the grand synthesis of heredity and Darwinism found in the neo-Darwinian model. Instead, and consistent with the four-dimensional and neo-Lamarckian system involved in human evolution[2], genes are a plastic feature of the four-dimensional, epigenetic, embodied organism ↔ context ontogenetic system that constitutes the fundamental, relational process of human development across the lifespan.

As suggested by Slavich and Cole[8], theory and research on the embodied, epigenetic relational developmental system has profound implications for applications to policies and health or positive development promotion programmes (also suggested by Lerner & Benson[22]). Indeed, based on current evidence onembodiment and plasticity in both phylogenetic and ontogenetic processes, we believe that collaborative multidisciplinary, biology-behavioural research framed within RDST, especially when coupled with change-sensitive, person-centred, rigorous methodology[32], will provide increasingly more nuanced information about the mutually influential relations among organisms and ecological processes and will enable biological and developmental science to be a productive means for promoting more positive, healthier developmental trajectories among all people.

The integrated scientific agenda that we believe is legitimated by the contemporary research in evolutionary biology, epigenetics (including human social genomics), and developmental science suggests that scholars should be able to undertake programmatic research specifying "what" characteristics, of "what" individuals, may be integrated with "what" features of the ecology of human development, at "what" points across ontogeny, to produce "what" instances of (more optimal) changes in human behaviour and development.

Conclusion

Integrated, biology–human development research along the lines we have suggested affords optimism that future research will produce new, and actionable, information about how we can promote changes that enhance more positive development among all people across the life course and across generations.

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